AL

(1)

Japanese Kokai Patent Application No. Hei 7[1995]-252651

Fujitsu

Translated from Japanese by the Ralph McElroy Translation Company
910 West Avenue, Austin, Texas 78701 USA

Code: 598-75071
Ref: 2390/MD/L/B/MBE-3600

JAPANESE PATENT OFFICE

PATENT JOURNAL

KOKAI PATENT APPLICATION NO. HEI 7[1995]-252651

Int. Cl.[6]:	C 23 C 14/35 H 01 L 21/203
Sequence Nos. for Office Use:	8414-4K 8719-4M
Filing No.:	Hei 6[1994]-44345
Filing Date:	March 15, 1994
Publication Date:	October 3, 1995
No. of Claims:	6 (Total of 5 pages; OL)
Examination Request:	Not filed

MAGNETRON SPUTTERING DEVICE AND METHOD OF DEPOSITION OF METAL THIN FILM

Inventor:	Hidehiko Oshima Fujitsu VLSI Co., Ltd. 2-1844-2 Kozoji-cho, Kasugai-shi, Aichi-ken
Applicants:	000005223 Fujitsu, Ltd. 1015 Kamiodanaka, Nakahara-ku, Kawasaki-shi
	000237617 Fujitsu VLSI Co., Ltd. 2-1844-2 Kozoji-cho, Kasugai-shi, Aichi-ken
Agent:	Hiroyoshi Onda, patent attorney

[There are no amendments to this patent.]

Abstract

Purpose:

The purpose of this invention is to improve the uniformity of the plasma density on the surface of the target and the uniformity of the sputtering film thickness, and to prolong the lifetime of the target.

Constitution:

Ring-shaped closed magnetic field CMF is formed on the surface of target (13) by means of a magnet assembly having plural magnets (12) set in order; with respect to said target (13), one of said plural magnets (12) is positioned on central line OR of said target (13); and the magnet assembly is rotated parallel to target (13) around central line OR. Among plural magnets (12), the magnets set nearer to central line OR of target (13) form lower magnetic field.

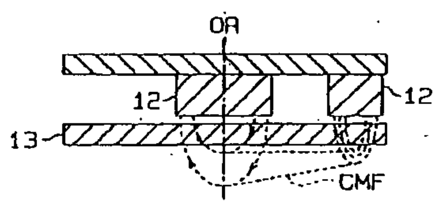

Figure illustrating principle of this invention.

Claims

1. A type of magnetron sputtering device, characterized by the following facts:

ring-shaped closed magnetic field (CMF) is formed on the surface of target (13) by means of a magnet assembly having plural magnets (12) set in order; with respect to said target (13), one of said plural magnets (12) is positioned on central line (OR) of said target (13); and in this state the magnet assembly is rotated parallel to target (13) around central line (OR);

in this magnetron sputtering device, among said plural magnets (12), the magnets positioned nearer to central line (OR) of target (13) form the lower magnetic field.

2. The magnetron sputtering device described in Claim 1, characterized by the fact that for said plural magnets (12), for those set nearer the center of said target (13), the gap between S-pole and N-pole is larger.

3. The magnetron sputtering device described in Claim 1, characterized by the fact that among said plural magnets, the magnets set nearer to the center of said target have lower magnetic flux density.

4. The magnetron sputtering device described in Claim 1, characterized by the fact that among said plural magnets, the magnets set near the center of said target have a larger distance between the surface of the magnet and the target.

5. The magnetron sputtering device described in Claim 1, characterized by the fact that among said plural magnets, for the magnets set near the center of said target, a ferromagnetic member is included between them and said target.

6. A method for deposition of metal thin film, characterized by the fact that magnetron sputtering is carried out with the closed magnetic field applied to the target higher for the portion near the center of the target than the portion near the periphery.

Detailed explanation of the invention

[0001]

Industrial application field

This invention pertains to a type of magnetron sputtering device which has a ring-shaped closed magnetic field rotating along the surface of the target.

[0002]

In the manufacturing operation of semiconductor devices, there is a step in which a metal thin film of aluminum, titanium, or the like is formed on a wafer. An example of a device used in this step of operation is the magnetron sputtering device that sputters metal particles from a target made of said metal onto the surface of the wafer. For the metal thin film formed on the surface of the wafer by the magnetron sputtering device, it is necessary to ensure uniformity of the film.

[0003]

Prior art

The structure of the conventional magnetron sputtering device can be explained by reference to Figures 8 and 9.

[0004]

On magnet substrate (1) in disk shape, as shown in Figures 8 and 9, plural magnets (2) are set in a ring configuration from center OR of said magnet substrate (1) to the periphery. Each

magnet (2) has an N-pole set on the inner peripheral side and an S-pole set on the outer peripheral side. As shown in Figure 9, closed magnetic field CMF is formed by magnets (2).

[0005]

Said magnet substrate (1) is rotated by a driving shaft (not shown in the figure) around said center OR as the rotating axis. Target (3) made of a metal, for sputtering say, aluminum, is set at a position near the side of installation of magnet (2) on said magnet substrate (1). Said target (3) is formed as a circular plate having the same diameter as that of magnet substrate (1). Its center is positioned on the extension line of center OR of magnet substrate (1).

[0006]

As magnet substrate (1) with the aforementioned configuration is rotated around center OR as the rotating center, said closed magnetic field CMF rotates parallel to target (3) around center OR as the rotating center.

[0007]

In closed magnetic field CMF, plasma PL is generated, and said plasma PL, which is enclosed in closed magnetic field CMF, is irradiated on the surface of target (3) while moving. Consequently, plasma PL hits the surface of target (3) sequentially, aluminum particles are knocked out from said target (3), and an aluminum thin film is sputtered on the surface of wafer (4) shown in Figure 10. In this case the surface of target (3) is cut sequentially from the center to the periphery.

[0008]

Then, the sputtered aluminum thin film is etched to form a pattern in the next step of operation. In this way aluminum wiring is formed.

[0009]

Problems to be solved by the invention

In the aforementioned magnetron sputtering device, the central portion of target (3) is always exposed to closed magnetic field CMF, and is always under irradiation of plasma PL. On the other hand, the region other than the central portion of target (3) is exposed to closed magnetic field CMF only for a prescribed period of time, and is not always irradiated with plasma PL.

[0010]

Consequently, as shown in Figure 10, for the aluminum particles sputtered on region A on the surface of wafer (4), the sputtering amount in the direction from the periphery of target (3) is larger than the sputtering amount in the direction from the center of said target (3).

[0011]

In this state, for example, as shown in Figure 11, when aluminum thin film (6) is formed on contact hole or other dip (5) formed on wafer (4), the film thickness is nonuniform in the step portion. This is a problem.

[0012]

Also, the aluminum particles knocked out from the central portion of target (3) are attached to target (3) again. As the re-attached particles are sputtered out again, they become dust in the sputtering device, adversely affecting formation of the aluminum thin film and the later steps of operation.

[0013]

Also, in the central portion of target (3), the density of plasma PL is higher, while in the region other than the central portion of target (3), the density of plasma PL is lower. As the sputtering rate in the central portion of target (3) is higher, the surface of target (3) is not cut off uniformly. Consequently, the lifetime of target (3) becomes shorter. This is a problem.

[0014]

The purpose of this invention is to solve the aforementioned problems of the prior art by providing a type of magnetron sputtering device, characterized by the fact that it has higher uniformity in the plasma density on the surface of the target, higher uniformity in the sputtering film thickness, and longer lifetime of the target.

[0015]

Means to solve the problems

Figure 1 is a diagram illustrating the principle of this invention. Ring-shaped closed magnetic field CMF is formed on the surface of target (13) by means of a magnet assembly having plural magnets (12) set in order; with respect to said target (13), one of said plural magnets (12) is positioned on central line OR of said target (13), and the magnet assembly is rotated parallel to target (13) around central line OR. For plural magnets (12), the magnets set nearer to central line OR of target (13) form the lower magnetic field.

[0016]

Also, as shown in Figure 2, among said plural magnets (12), for the magnets set nearer to the center of said target (13), the gap between S-pole and N-pole is larger. Also, among said plural magnets, those set nearer to the center of said target have lower magnetic flux density.

[0017]

Also, among said plural magnets, for those set near the center of said target, the distance between the surface of the magnet and the target is larger. Also, among said plural magnets, for the magnets set near the center of said target, a ferromagnetic member is included between them and said target.

[0018]

Functions

The central portion of target (13) is always exposed to a lower magnetic field while the peripheral portion of target (13) is exposed to a higher magnetic field for a limited period of time. Consequently, the plasma density irradiated on the surface of target (13) is made uniform on the surface of target (13).

[0019]

Application examples

In the following, this invention will be explained in more detail with reference to an application example. As shown in Figures 2 and 3, on disk-shaped magnet substrate (11), 12 magnets (12) are set in a ring configuration from center OR to the periphery of magnet substrate (11).

[0020]

For each magnet (12), an N-pole is set on the outer peripheral side while an S-pole is set on the inner peripheral side. The area of N-pole is equal to that of S-pole. The gap between S-pole and N-pole of said magnet (12) is selected to become larger as the position is nearer to center OR of said magnet substrate (11). The gap between S-pole and N-pole of magnet (12) positioned at center OR is the largest.

[0021]

The ratio of the smallest gap between S-pole and N-pole to the largest gap between them of said magnets (12) is about 1:2 - 1:4. Consequently, closed magnetic field CMF (1), formed by

magnet (12) set at the central portion of magnet substrate (11) shown in Figure 4, is lower than the closed magnetic field CMF (2), formed by magnet (12) set on the peripheral portion of magnet substrate (11) shown in Figure 5.

[0022]

Said magnet substrate (11) is rotated by a driving shaft (not shown in the figure) around said center OR as the rotating axis. Target (13) made of a metal for sputtering, say, aluminum, is set at a position near the side of installation of magnets (12) on said magnet substrate (1). Said target (13) is formed as a circular plate having the same diameter as that of magnet substrate (11). Its center is positioned on the extension line of center OR of magnet substrate (11).

[0023]

As magnet substrate (11) with the aforementioned configuration is rotated around center OR as the rotating center, said ring-shaped closed magnetic field CMF formed by said magnets (12) rotates parallel to target (13) around center OR as the rotating center.

[0024]

In closed magnetic field CMF, plasma PL is generated, and said plasma PL, which is enclosed in closed magnetic field CMF, is irradiated on the surface of target (13) while moving. Consequently, plasma PL hits the surface of target (13) sequentially, and aluminum particles are knocked out from said target (13) and an aluminum thin film is sputtered on the surface of wafer (4) shown in Figure 10.

[0025]

In this case, the central portion of target (13) is always exposed to a lower closed magnetic field while the peripheral portion of target (13) is exposed to a higher closed magnetic field for a limited time. Consequently, as shown in Figure 6, for region A on the surface of wafer (14), the sputtering amount in the direction from the periphery of target (13) and the sputtering amount in the direction from the center of target (13) become uniform.

[0026]

In this state, as shown in Figure 7, when aluminum thin film (16) is formed on contact hole or other dip on wafer (14), the film thickness on the step portion becomes uniform.

[0027]

Also, as the aluminum particles are knocked out uniformly from the surface of target (13), re-attachment of the knocked-out aluminum particles on target (13) is inhibited. Consequently, dust formation in the sputtering device can be prevented.

[0028]

Also, the plasma density on the surface of target (13) is constant, and the sputtering rate on the surface of target (13) also can be maintained constant. Consequently, the surface of said target (13) is cut off uniformly, and the lifetime of target (3) can be prolonged.

[0029]

In the aforementioned application example, the intensity of the closed magnetic field is changed by changing the gap between S-pole and N-pole. However, it is also possible to change the distance between the surface of the magnet and the target, or to arrange a ferromagnetic member between the target and the magnets set near the center of the target to change the intensity of the closed magnetic field.

[0030]

Effect of the invention

As explained in detail above, this invention can provide a magnetron sputtering device with high uniformity of the plasma density on the surface of the target, high uniformity of the sputtering film thickness, and longer lifetime of the target.

<u>Brief description of the figures</u>

Figure 1 is a diagram illustrating the principle of this invention.

Figure 2 is a front view of the magnet assembly in an application example.

Figure 3 is a cross-sectional view illustrating the relative positions of the magnet assembly and the target.

Figure 4 is a diagram illustrating the closed magnetic field of magnets rotating at the central portion of the target.

Figure 5 is a diagram illustrating the closed magnetic field of magnets rotating at the peripheral portion of the target.

Figure 6 is a diagram illustrating the sputtering operation in an application example.

Figure 7 is a cross-sectional view illustrating the sputtering film formed by the sputtering operation in an application example.

Figure 8 is a front view illustrating the magnet assembly in a conventional device.

Figure 9 is a cross-sectional view illustrating the relative positions of the magnet assembly and target in the conventional device.

Figure 10 is a diagram illustrating the sputtering operation in the conventional device.

Figure 11 is a cross-sectional view of the sputtering film formed in the sputtering operation in the conventional device.

Brief explanation of symbols

12	Magnet
13	Target
CMF	Closed magnetic field
OR	Central line

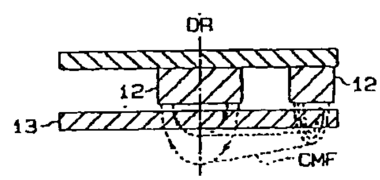

Figure 1. Diagram illustrating the principle of this invention

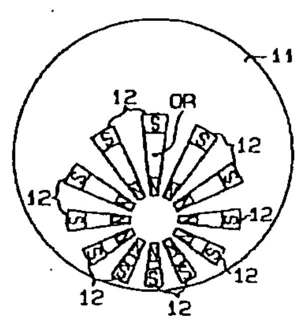

Figure 2. Front view of the magnet assembly in an application example

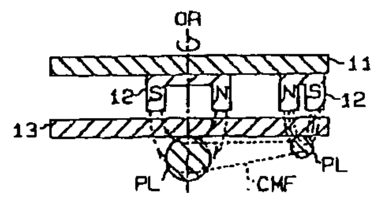

Figure 3. Cross-sectional view illustrating the relative positions of the magnet assembly and the target.

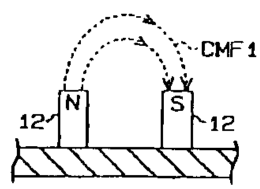

Figure 4. Diagram illustrating the closed magnetic field of magnets rotating at the central portion of the target.

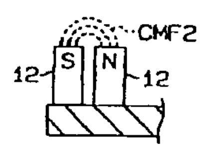

Figure 5. Diagram illustrating the closed magnetic field of magnets rotating at the peripheral portion of the target.

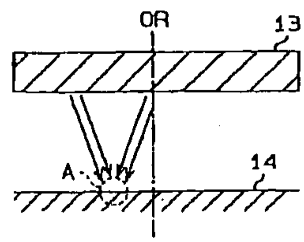

Figure 6. Diagram illustrating the sputtering operation in an application example

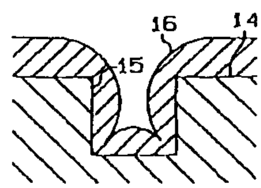

Figure 7. Cross-sectional view illustrating the sputtering film formed by the sputtering operation in an application example.

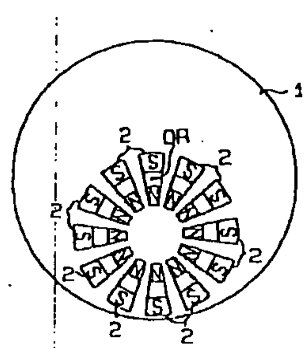

Figure 8. Front view illustrating the magnet assembly in a conventional device

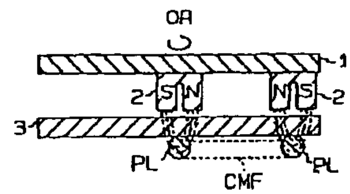

Figure 9. Cross-sectional view illustrating the relative positions of the magnet assembly and target in the conventional device.

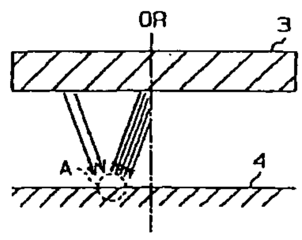

Figure 10. Diagram illustrating the sputtering operation in the conventional device

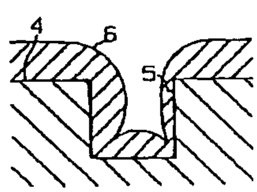

Figure 11. Cross-sectional view of the sputtering film formed in the sputtering operation in the conventional device.